Radioactive Beams with a High Intensity Proton Driver: The EURISOL Project

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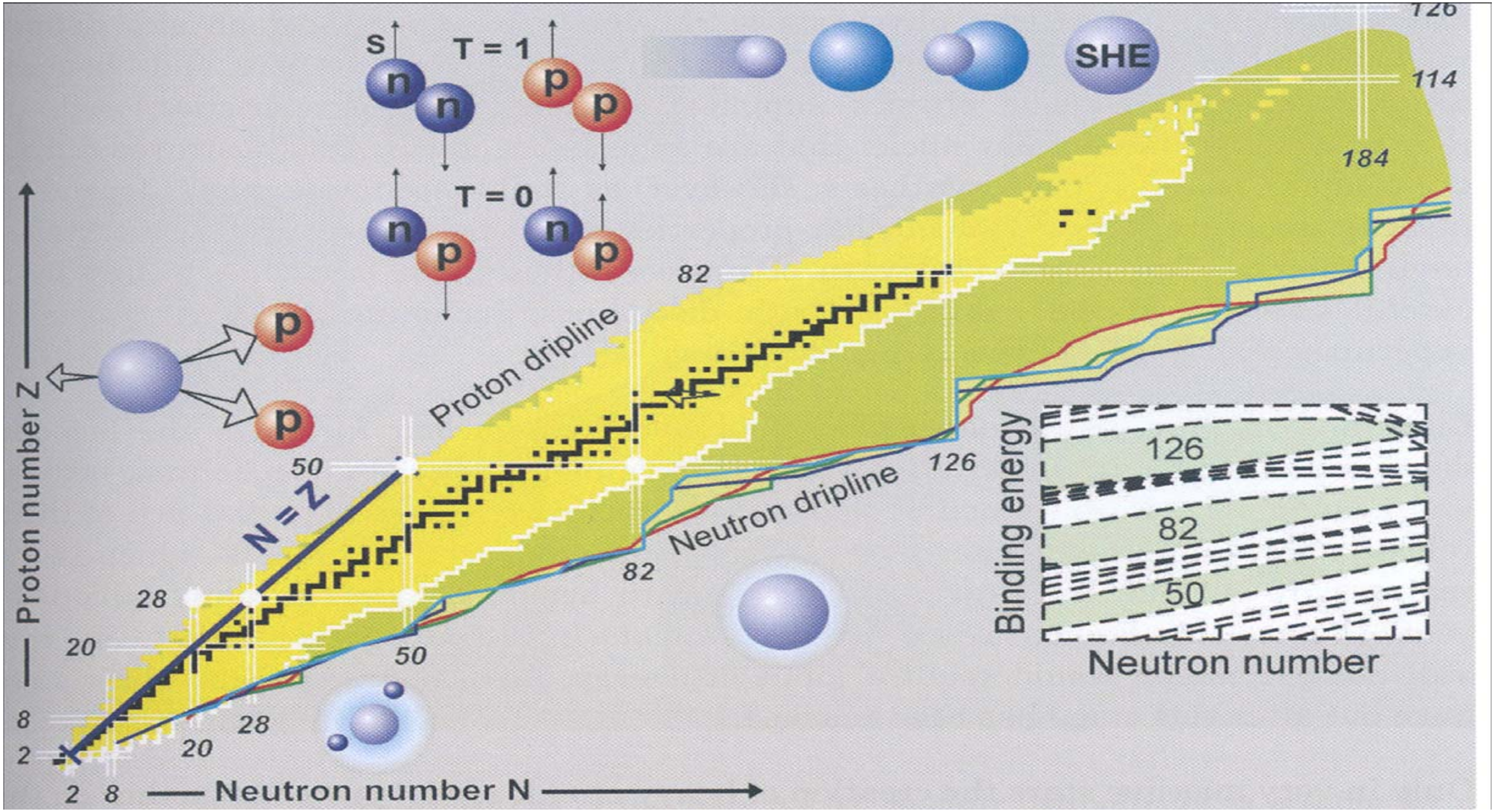
Yorick Blumenfeld

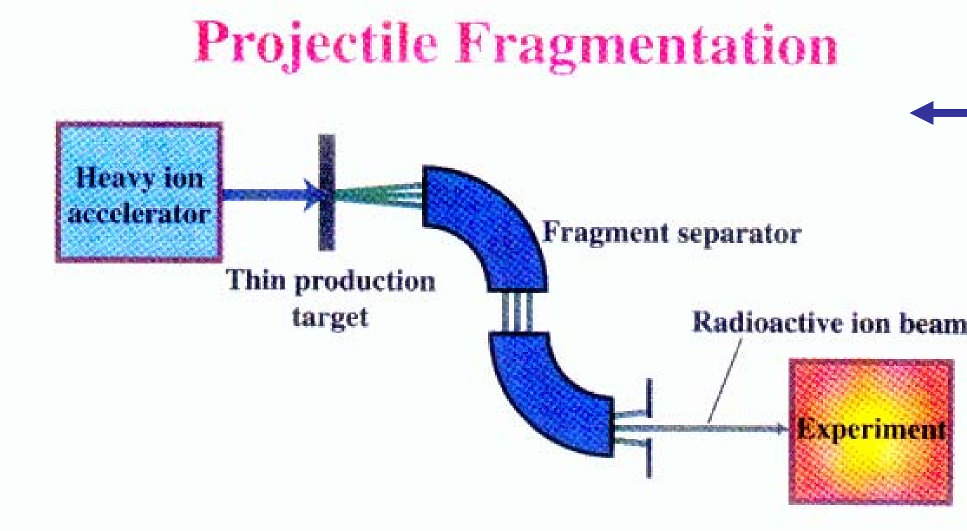
EURISOL Design Study

IPN Orsay

The Nuclear Chart and Challenges



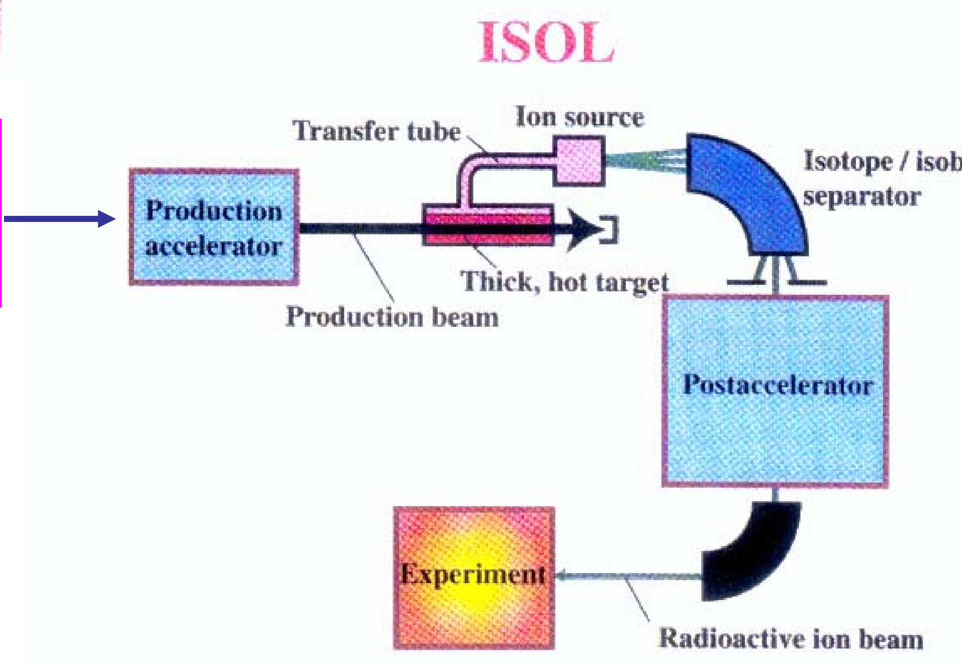
Radioactive beam production: Two complementary methods



GANIL/SISSI, GSI, RIKEN, NSCL/MSU

High energy, large variety of species, Poor optical qualities

GANIL/SPIRAL, REX/ISOLDE, ISAAC/TRIUMF



Low energy, chemistry is difficult, good beam qualities

THE EUROPEAN PLAN

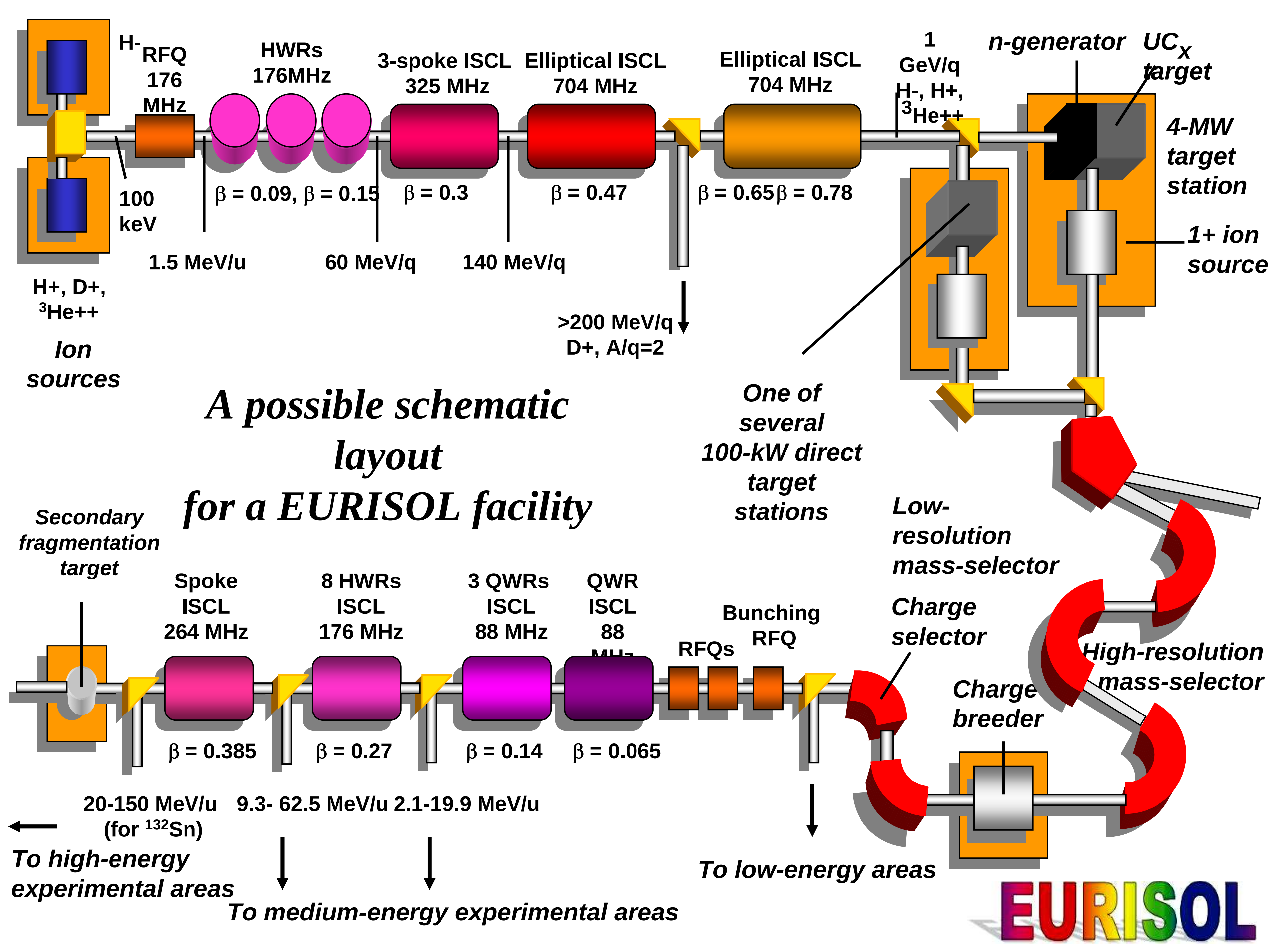
NuPECC recommends the construction of 2 ‘next generation’ RIB infrastructures in Europe, i.e. one ISOL and one in-flight facility. The in-flight machine would arise from a major upgrade of the current GSI facility: FAIR, while EURISOL would constitute the new ISOL facility

The EURISOL Road Map

- Vigorous scientific exploitation of current ISOL facilities : EXCYT, Louvain, REX/ISOLDE, SPIRAL
- Construction of intermediate generation facilities: SPIRAL2, HIE-ISOLDE, SPES
- Design and prototyping of the most specific and challenging parts of EURISOL in the framework of EURISOL_DS.

The EURISOL_DS in the 6th framework

- Detailed engineering oriented studies and technical prototyping work
- 20 participants from 13 countries
- 21 contributors from Europe, Asia and North America
- Total Cost : 33 M€
- Contribution from EU : 9.16 M€
- Continues to July 2009
- 12 Tasks in 4 Topical Areas:
  - Targets
  - Accelerators
  - Physics, beams and Safety
  - Beta Beams



A possible schematic layout for a EURISOL facility
H-
RFQ 176 MHz
HWRs 176MHz
3-spoke ISCL 325 MHz
Elliptical ISCL 704 MHz
Elliptical ISCL 704 MHz
1 GeV/q H-, H+, 3He++
n-generator
UCx target
4-MW target station
1+ ion source
100 keV
β = 0.09, β = 0.15
β = 0.3
β = 0.47
β = 0.65β = 0.78
1.5 MeV/u
60 MeV/q
140 MeV/q
H+, D+, 3He++
Ion sources
>200 MeV/q D+, A/q=2
One of several 100-kW direct target stations
Low-resolution mass-selector
Secondary fragmentation target
Spoke ISCL 264 MHz
8 HWRs ISCL 176 MHz
3 QWRs ISCL 88 MHz
QWR ISCL 88
Bunching RFQ
RFQs
Charge selector
High-resolution mass-selector
Charge breeder
β = 0.385
β = 0.27
β = 0.14
β = 0.065
20-150 MeV/u (for 132Sn)
9.3- 62.5 MeV/u
2.1-19.9 MeV/u
To high-energy experimental areas
To medium-energy experimental areas
To low-energy areas
EURISOL

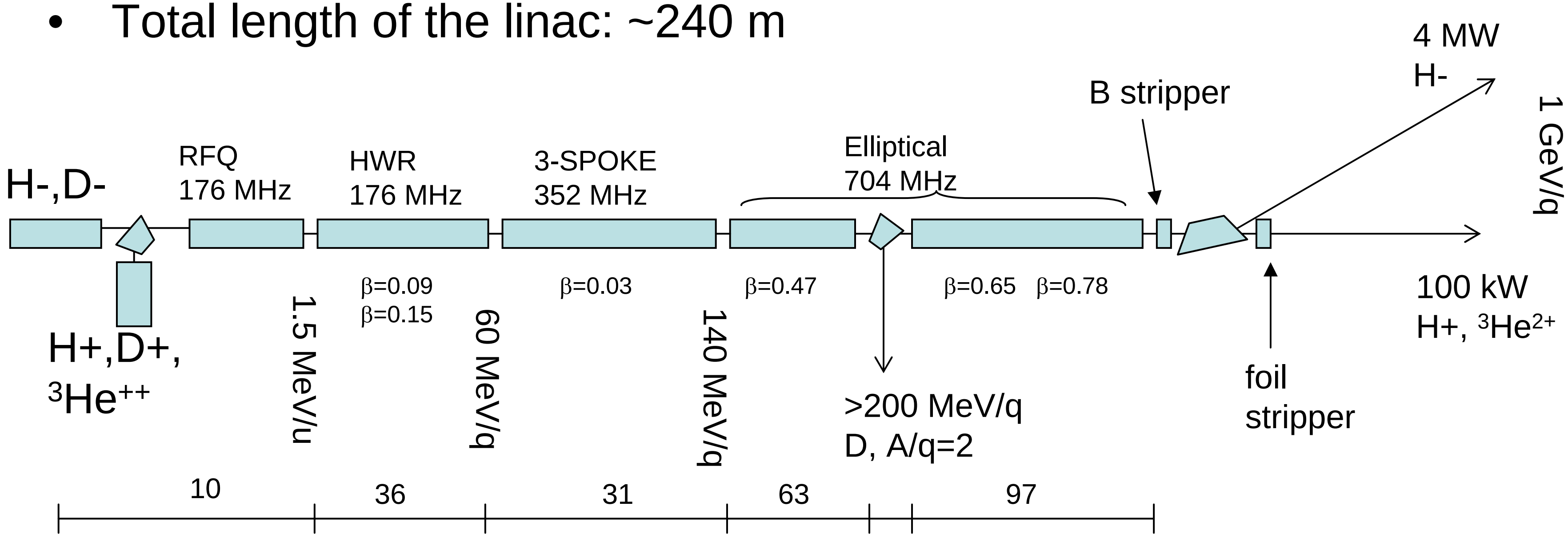
EURISOL Design Study

The Main Challenges of the DS

- Design a 5MW; 1GeV proton driver with additional capability of 200 AMeV deuterons and A/Q=2 Heavy Ions (Task7) ; build and test prototypes of the cavities (task 8).
- Design a liquid Hg converter which will accept 5 MW of beam power (task 2).
- Design a UCx target which will make the most efficient use of the neutrons produced (task 4).
- Evaluate the safety constraints of the above set up (task 5).
- Design an efficient multi-user beam distribution system (task 9).
- Design a superconducting HI LINAC capable of accelerating ^{132}Sn up to 150 AMeV (task 6)
- Investigate technologies for the instrumentation of the future (task 10)
- Provide a conceptual study for a beta-beam neutrino facility (task 12).

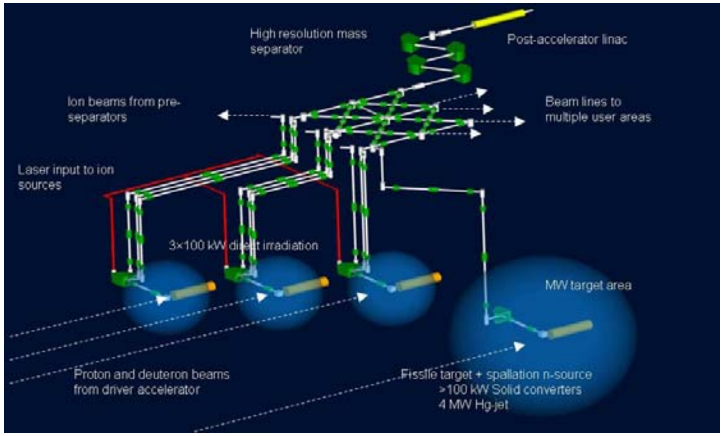
New baseline scheme with extended capabilities

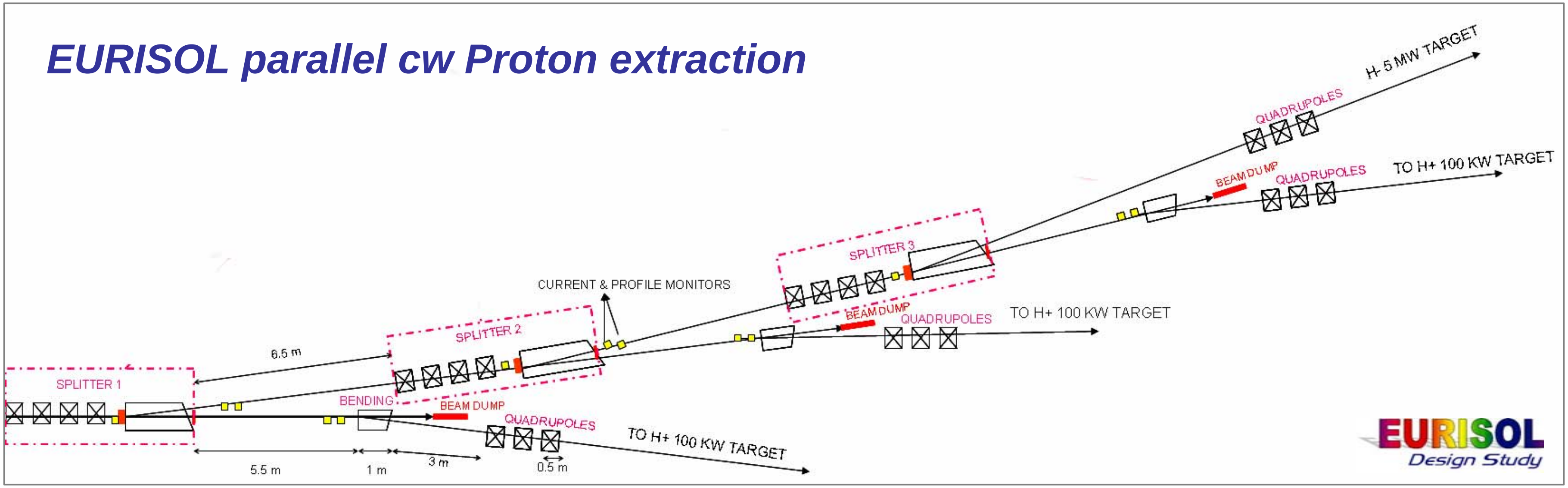
- 2 injection lines for H,D, He and A/q=2 ions
- SARAF scheme up to 60 MeV/q
- IPNO scheme from 60 to 140 MeV/q
- CEA scheme from 140 to 1000 MeV/u
- cw beam splitting at 1 GeV (1 line 4 MW + 3 lines 100 kW)
- Total length of the linac: ~240 m



1 GeV Multiple Extraction

- 3 splitting stations
- 4 simultaneous users for cw proton beams:
    - 1 × 4 MW
    - 3 × 0÷100 kW (continuously adjustable)
- <u>Unique ability of EURISOL</u> at present

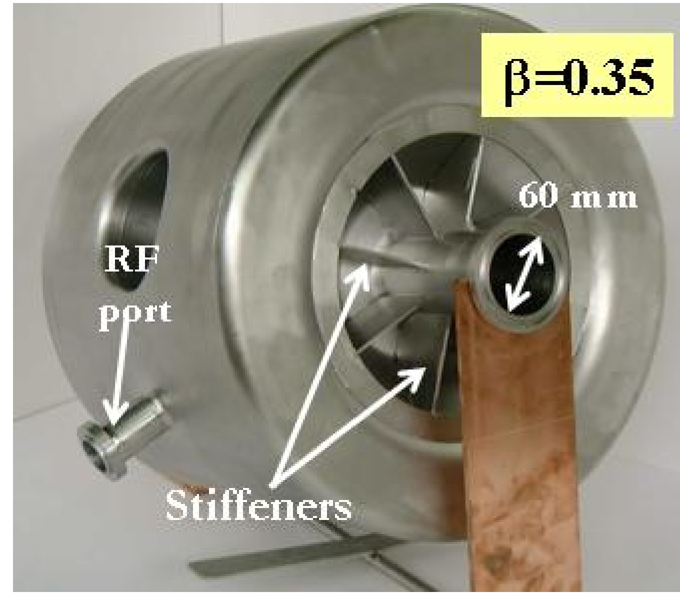




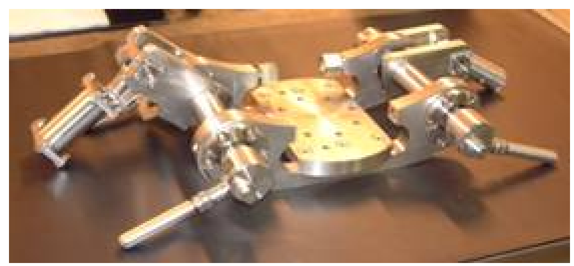
Spoke cavities development @ IPN Orsay

•2 prototypes at β=0.15 and β=0.35 fabricated and successfully tested at 4.2 K.

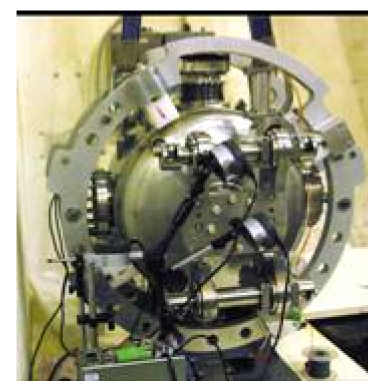
•This technology is the basis for the 3-Spoke required by the Driver linac



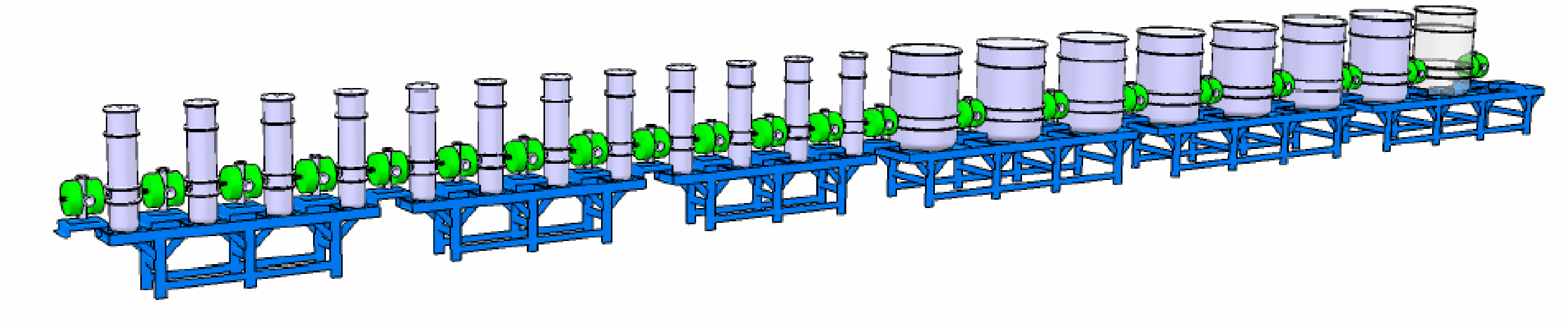
IPN
Orsay
Division Accélérateurs



Spoke cavity tuner



Design of the post-accelerator



SPIRAL-2 philosophy : Smoothest beam dynamics (regular FDO lattice, low number of β-sections), Modular solution and simple cryostats, Separated vacuum (safety with FP), Warm focusing (easier for alignement), Possibility to insert diagnostics at each period, ease of tuning

Main technical requirements:

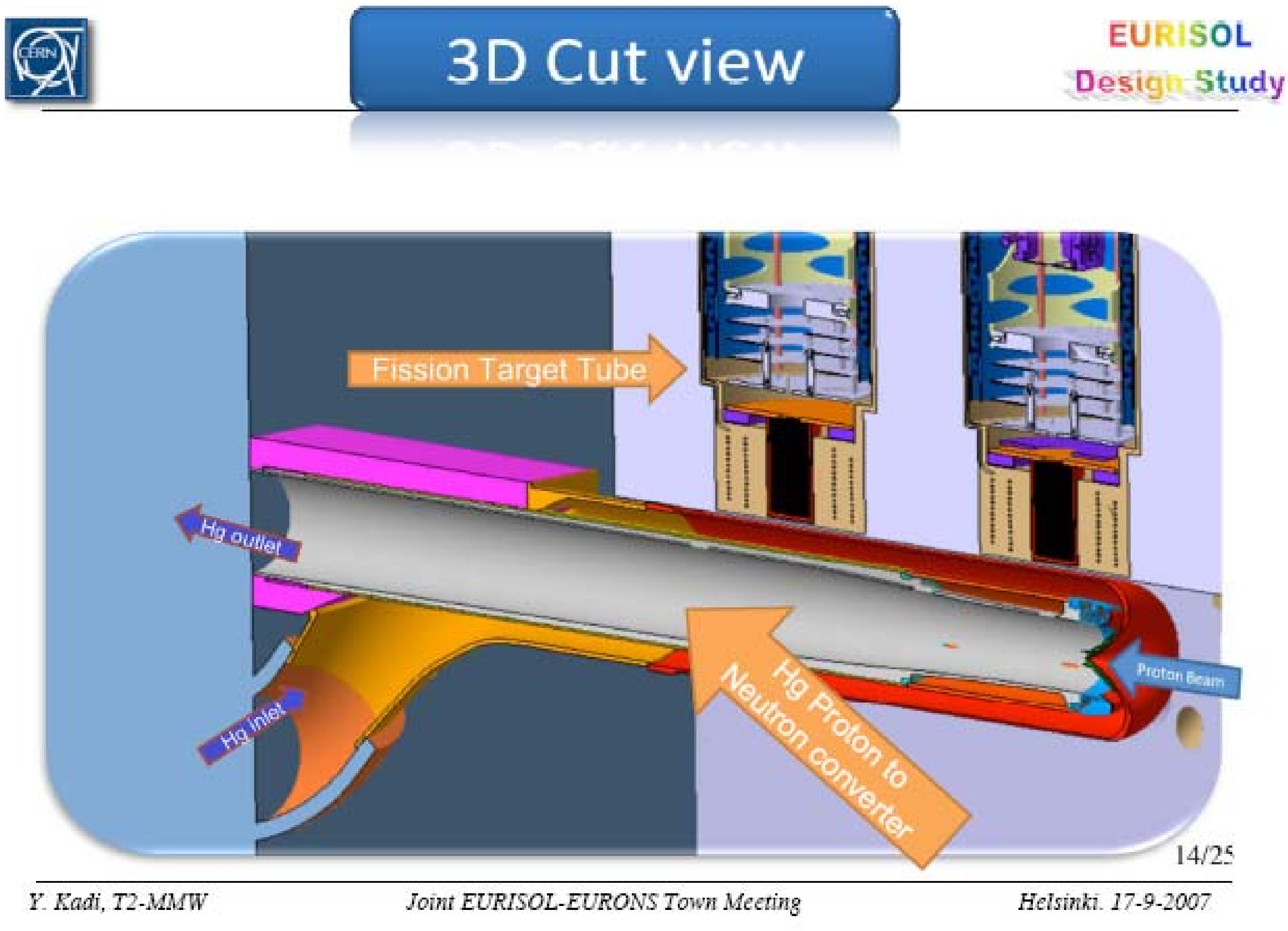
Only 2-gap cavities (high q/A acceptance)

Max. accelerating fields 7.8 MV/m

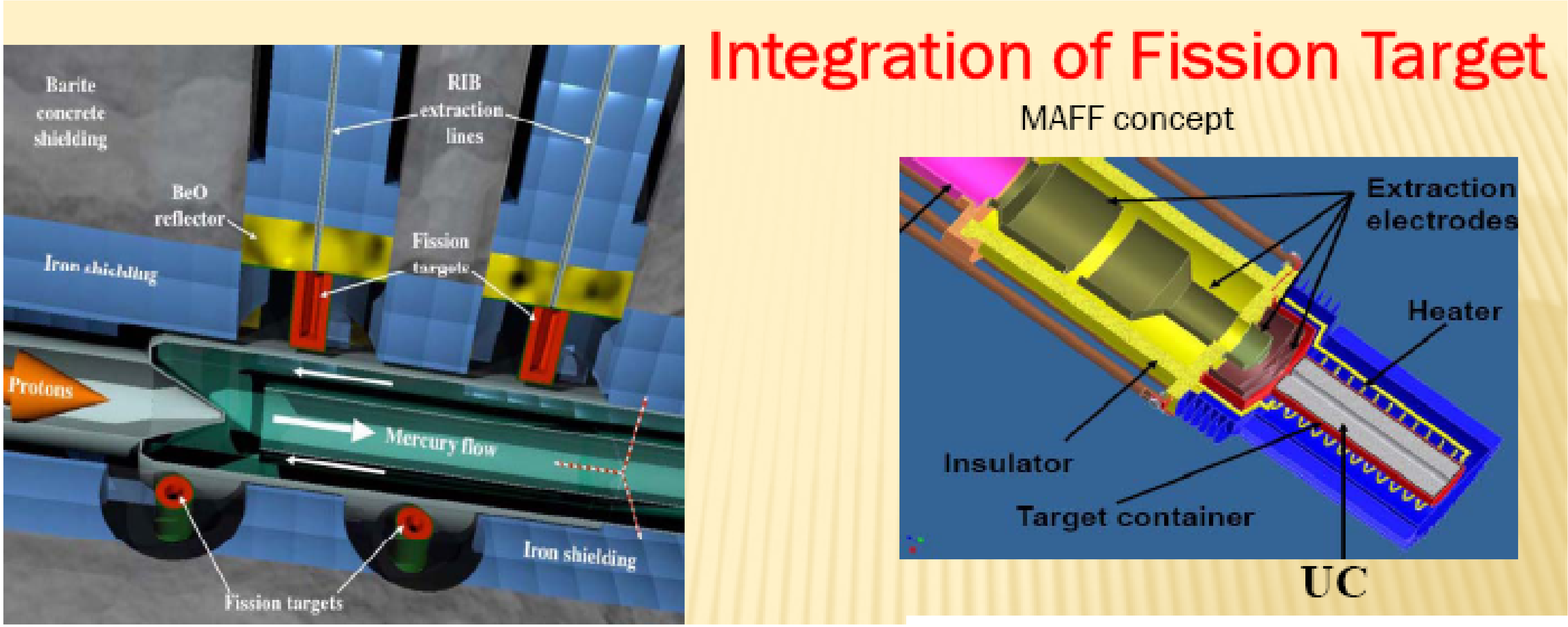
Nominal operation for A/Q between 4 and 8

$^{132}Sn^{25+}$	Section 1	Section 2	Section 3	Section 4	TOTAL
Cavity Freq.	88.05 MHz	88.05 MHz	176.1 MHz	264.15 MHz	-
Cavity β	0.065	0.14	0.27	0.385	-
# cav./ cryo	1 QWR	3 QWR	8 HWR	14 SPOKE	-
# cavities	15 cav	27 cav	80 cav	154 cav	**276 cav**
Length	17.9 m	26.1 m	59.0 m	103.8 m	**206.8 m**
Ouput energy range	-	2.1 – 19.9 MeV/A	9.3 – 62.5 MeV/A	20.0 – 150.0 MeV/A	**2.1 – 150.0 MeV/A**

New Target Concept

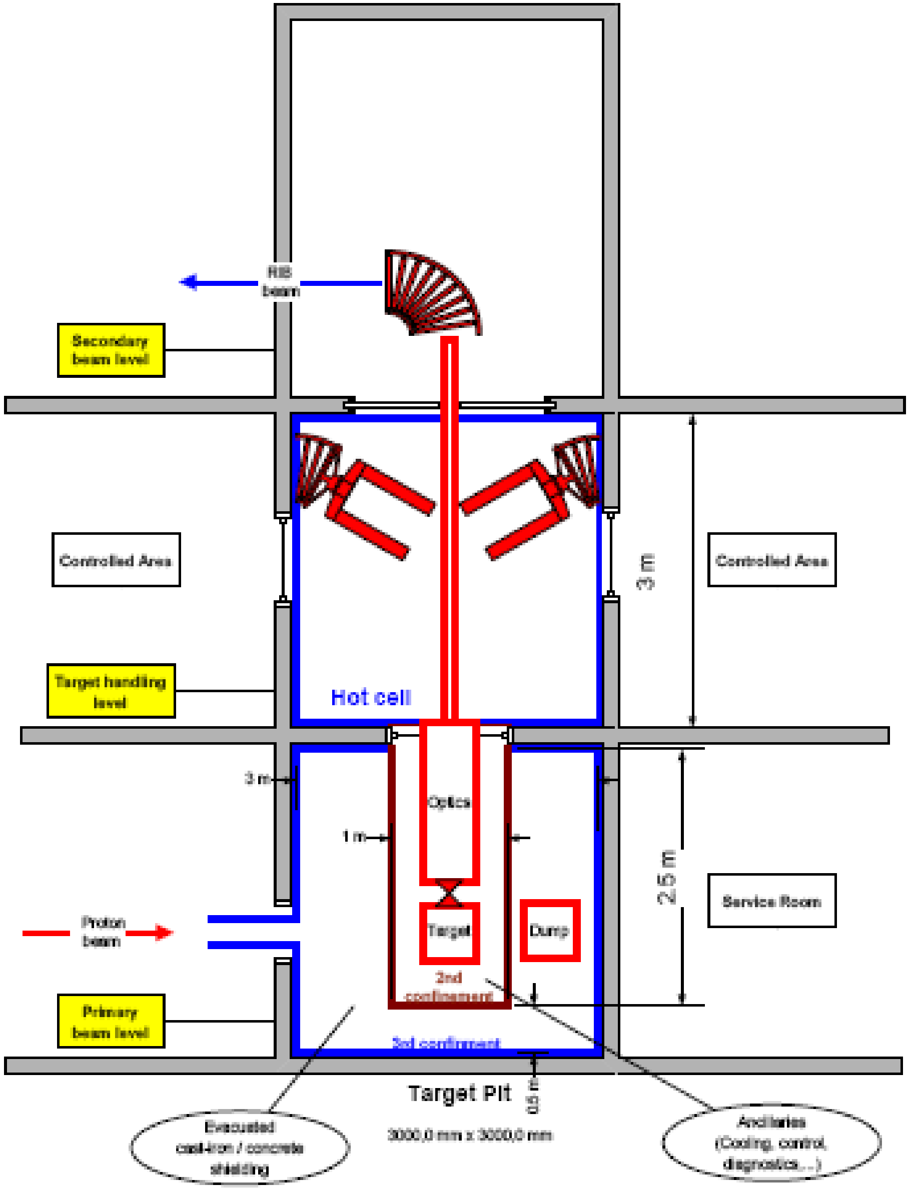


Reactor Type Target

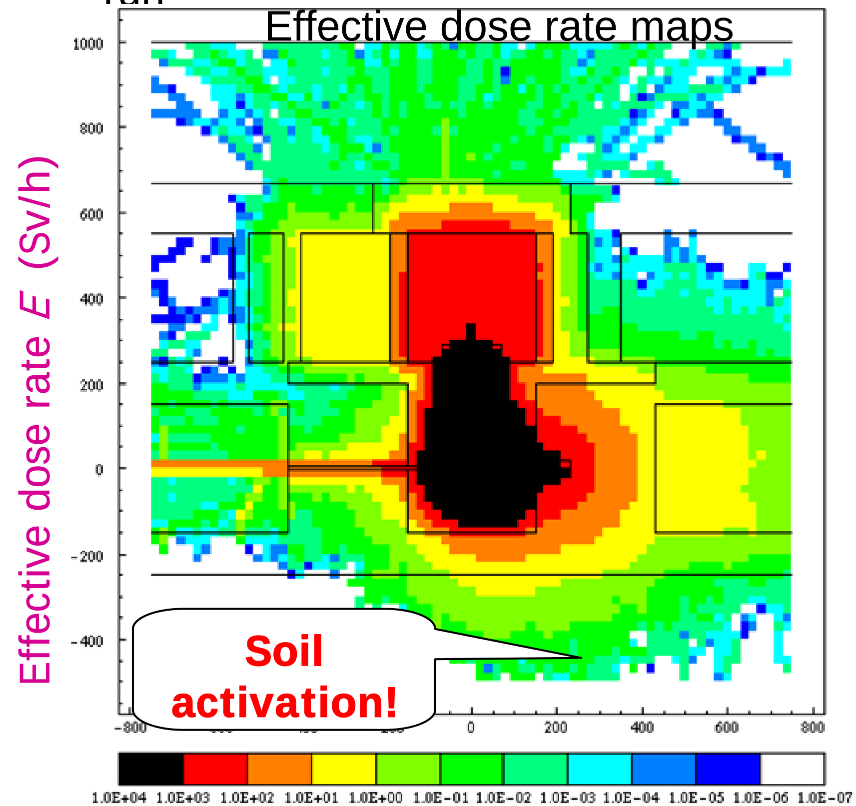


Concept Validated by International Advisory Board

Conceptual design of 100kW target station

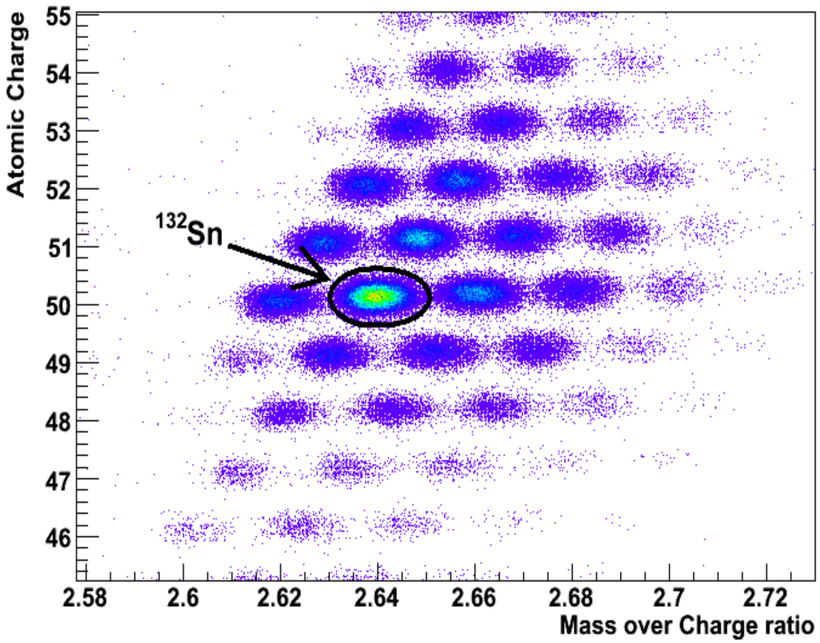


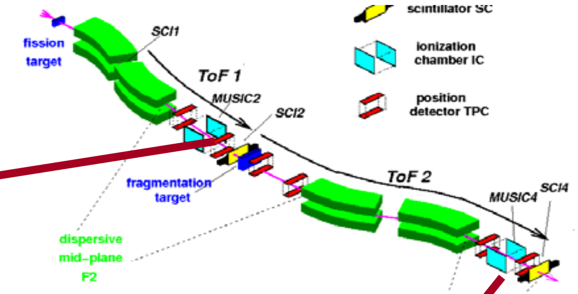
- Underground target position
- Front-end retracts vertically
- Hot-cell for target exchange
- Separator in 3rd level
- Neighboring hot-cell accessible during run



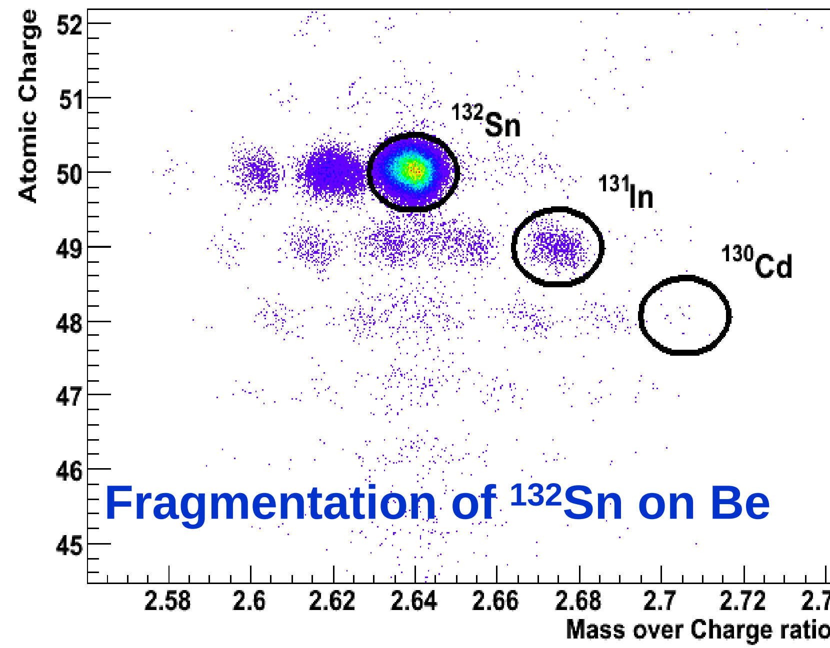
Fragmentation of ^{132}Sn (Preliminary results)

ID plot at dispersive foca plane (S2)



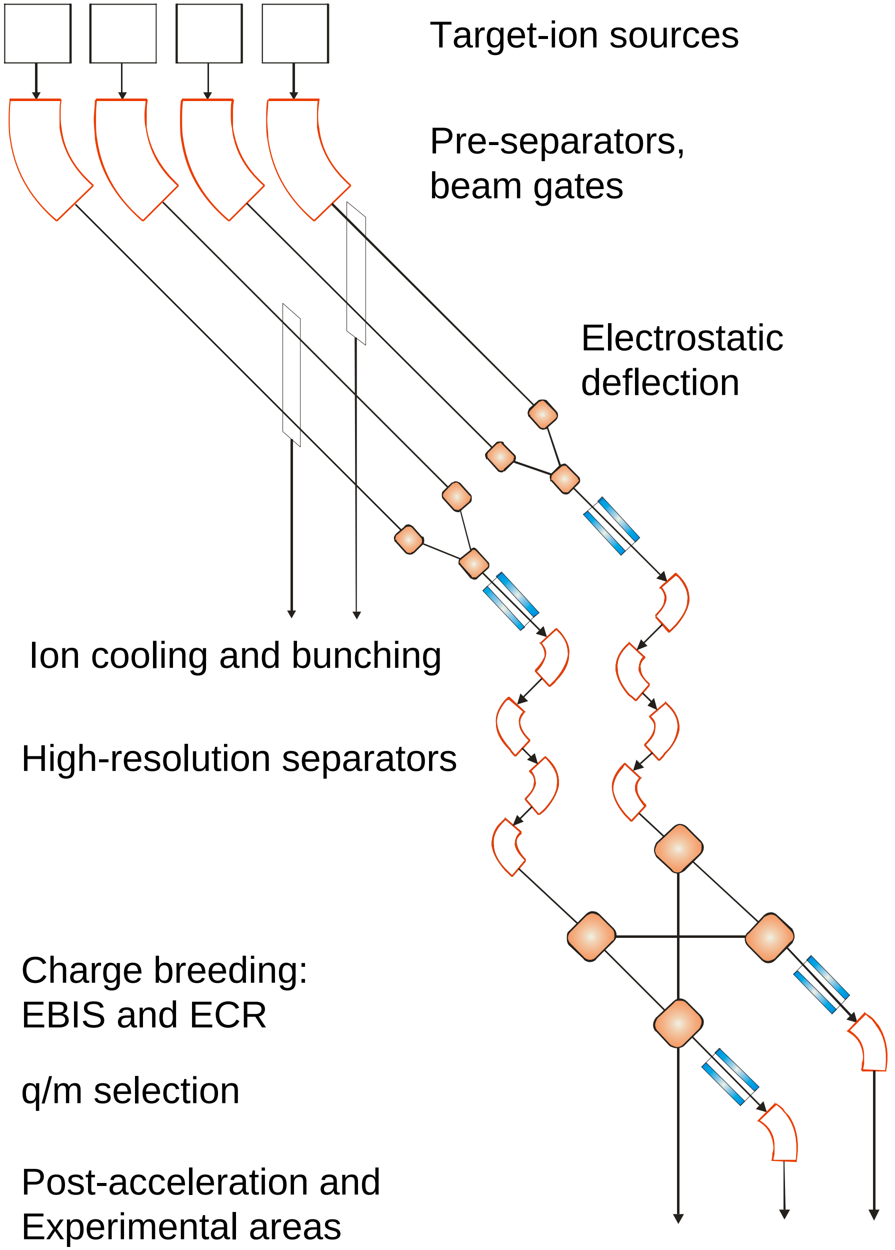


ID plot at S4 (selected ^{132}Sn)



D. Perez and D. Dragosavac

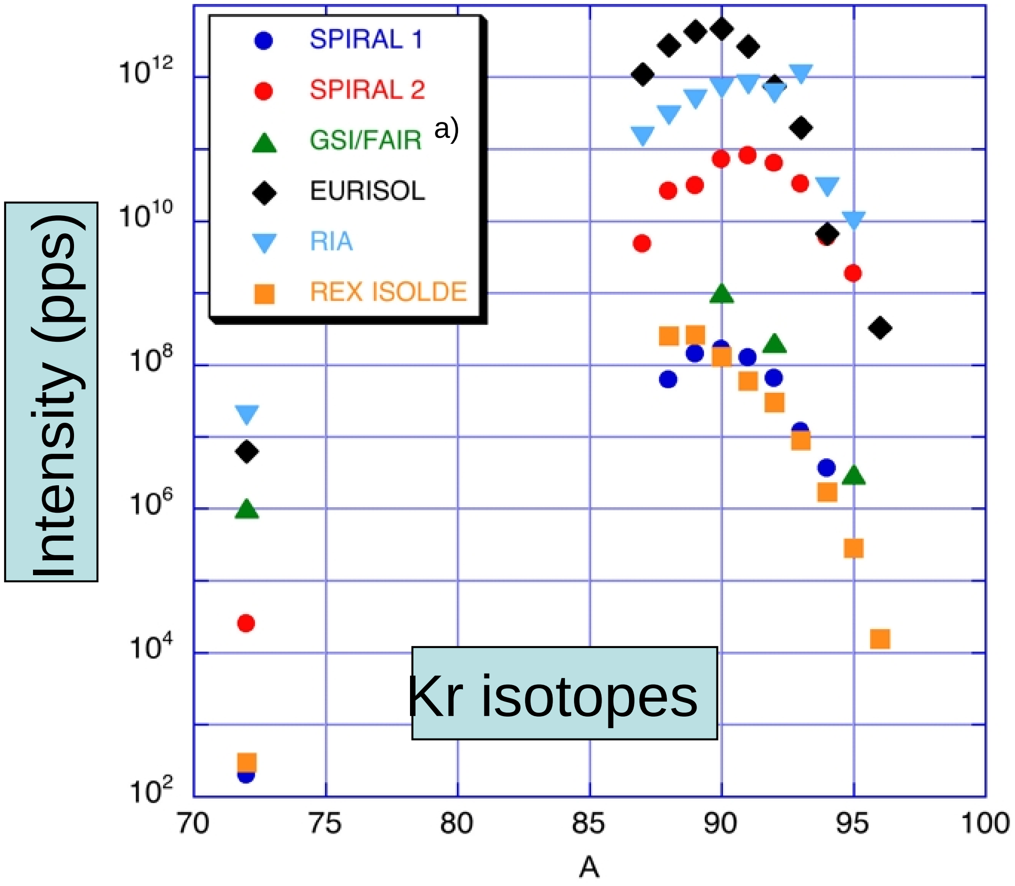
Schematic lay-out



Beam preparation lay-out:

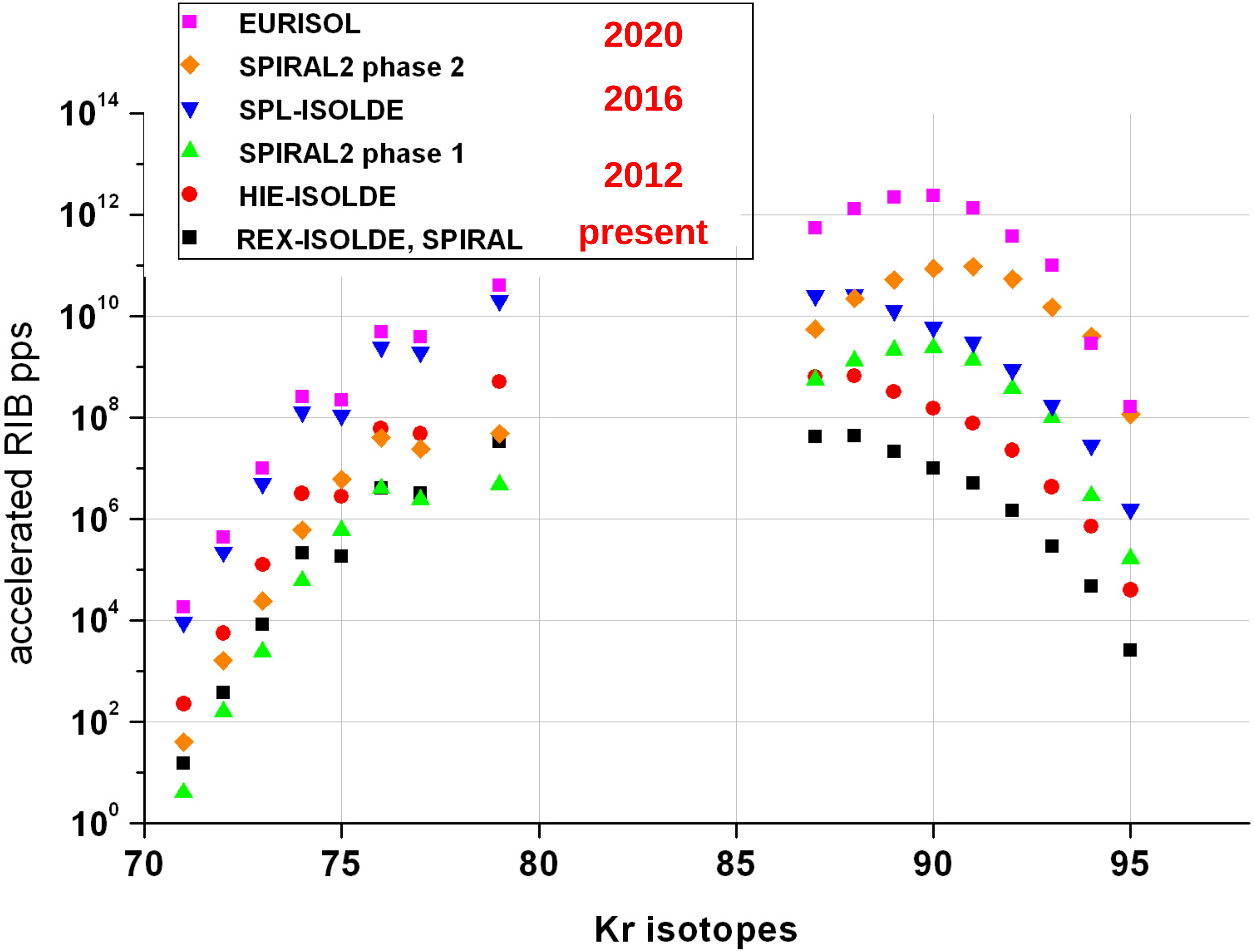
- Two complete beam preparation chains
- Two parallel mass-purified beams for on-line experiments
- Two charge breeders:
  - EBIS (fast, low capacity, low background, narrower charge state distribution, provides intensity also for light elements)
  - ECR (slow, high capacity, high background, access to intense beams including stable ones)
- Modular (easy to expand)
- Robust (electrostatic deflectors without moving parts)

Yields after acceleration
Comparison between facilities



a) Yield for in-flight production of fission fragments at relativistic energy

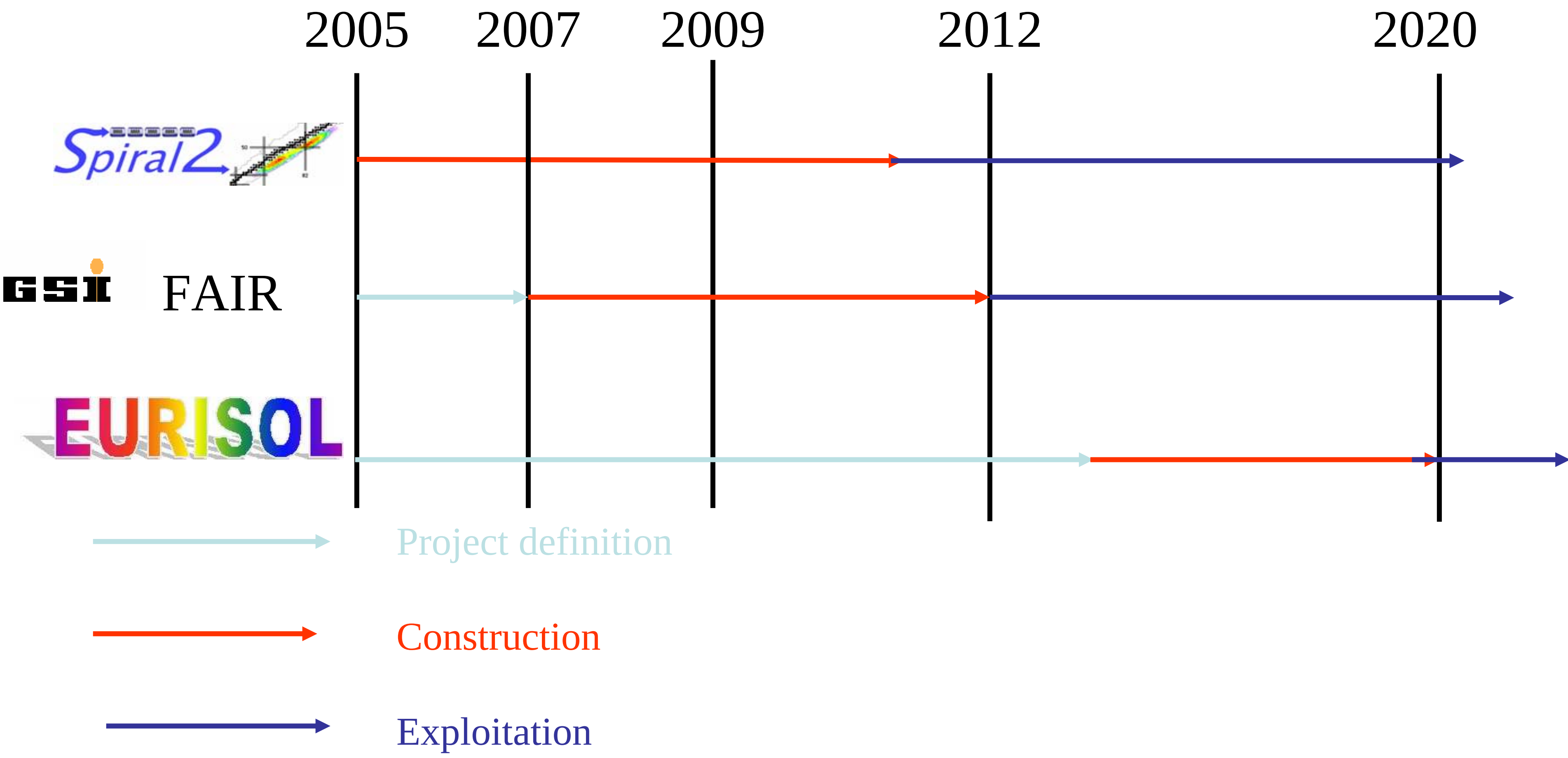
Radioactive ISOL beam yields



Possible Locations?

The Site Investigation Panel (chaired by Alan Shotter) is investigating the implementation and cost of EURISOL in these 3 hypotheses

Time scales


2005
2007
2009
2012
2020
Spiral2
GSI
FAIR
EURISOL
Project definition
Construction
Exploitation

The Future of EURISOL

- EURISOL has made use of EC instruments: 5th framework RTD and 6th framework DS.
- Major advances have been achieved and a large community with varied technical expertise has developed and must continue to be nurtured
- Full engineering report necessary before Pre-construction phase: No (evident) EC instrument for funding.
- We propose to form a EURISOL collaboration consisting of laboratories interested in participating in the continuing effort.
- EURISOL User Group in place. Elections of Executive Committee ongoing
- EUR-ISOL network in ENSAR Integrated Initiative to coordinate R&D work at ISOL facilities.